PEST CONTROL IN CANADA

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Alberta
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CONTENTS

TEACHERS GUIDE iii

INTRODUCTION iv

CHAPTER 1 POPULATION BIOLOGY OF PESTS 1
1.1 Introduction 1
1.2 What makes an organism a pest 2
1.3 The natural environment 3
1.4 The agricultural environment and pests 4
1.5 How pests prosper and their effect on agriculture 7
1.6 Summary 8
1.7 Questions 8
1.8 Suggested class activities 8

CHAPTER 2 AGRICULTURE AND FOOD PRODUCTION IN CANADA 9
2.1 Introduction 9
2.2 Food production in Canada 9
2.3 Agriculture in Canada today 11
2.4 Questions 12
2.5 Suggested class activities 12
2.6 References 12
Comment on agriculture 12

CHAPTER 3 THE PESTICIDE CONTROVERSY 14
3.1 Introduction 14
3.2 Pesticides, human health and wildlife 15
3.3 Pesticides in the environment 20
3.4 Summary 21
3.5 Questions 21
3.6 Suggested class activities 22
3.7 References 23

CHAPTER 4 GOVERNMENT CONTROL OVER PESTICIDES 23
4.1 Introduction 23
4.2 Pesticide approval 24
4.3 The pesticide label 27
4.4 Monitoring foods for pesticides 28
4.5 Summary 30
4.6 Questions 30
4.7 Suggested class activities 31
4.8 References 31

CHAPTER 5 PEST CONTROL 32
5.1 Introduction 32
5.2 Chemical methods of pest control 32
5.3 Resistance to chemical control 35
5.4 Cultural methods of pest control 37
5.5 Biological control 38
5.6 Integrated pest management 42
5.7 Summary 44
5.8 Questions 44
5.9 References 45

CHAPTER 6 MISCELLANEOUS METHODS OF PEST CONTROL 46
6.1 Introduction 46
6.2 Male sterilization 46
6.3 Genetic manipulation 47
6.4 Pheromones 48
6.5 Attractants 50
6.6 Growth hormones 50
6.7 Summary 50
6.8 Questions 51
6.9 References 51

Dear Biology 20 Teacher:

Within the last fifteen years, pesticides used by homeowners, farmers, foresters and others to control pests have become a very controversial subject. Some view these chemicals as being necessary to control pests for better food quality and quantity and for aesthetic reasons. Others view them as being unnecessary for pest control and suggest that Nature can take care of pests. Some feel that these chemicals degrade very rapidly in the environment and that they do not persist long enough to kill fish, birds and other wildlife. Others feel that they are harmful to human health and that they ruin our environment.

Pest Control in Canada describes the variety of methods that are used in agriculture to control pests and discusses the potential problems that could be posed by pesticides to the environment and human health. It outlines the scientific studies required before a pesticide is licensed for use and the monitoring procedures undertaken to ensure the environment is protected. This book also delves into the controversy over pesticides and assesses the beneficial versus harmful effects to human health and the environment.

Pest Control in Canada will fit in well with the **Ecology** portion of your Biology 20 curriculum. It was designed to be used in conjunction with Chapters 32 to 35 of your textbook entitled Biology – Living Systems by Oram, Hummer and Smoot. The scientific terms and concepts adopted in this book are compatible with those used in that textbook. A Teachers Guide in the back part of this book outlines how it can be used in conjunction with the Biology 20 text.

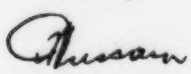
Pest Control in Canada can also be used separately as an independent unit in Ecology.

Whichever way you choose to use this book, I hope you and your students will find the information on this controversial subject interesting and thought-provoking.

This book has been reviewed by the Science Curriculum Committee of Alberta Education and field-tested by several Biology 20 teachers in the province. Their comments have been incorporated into this edition.

Copies of this book for you and your students can be obtained free from Alberta Agriculture, Crop Protection Branch. Films can be borrowed and videotaped without permission for your future use. All other publications can be obtained free of charge from Alberta Agriculture.

Yours truly,



Moe Hussain
for
Alberta Agriculture

INTRODUCTION

Most of the foods we eat are the product of agriculture. A substantial amount of this food is grown in Canada, although some is imported from other countries, particularly the United States. The number of farmers in this country is quite small, but their total agricultural production is high due in part to the effective control of pests. These pests such as weeds, insects and diseases can inflict considerable damage to crops, but a number of methods exist which a farmer can use to keep them under control.

The aim of this text is to inform students about several aspects of agriculture and pest control in Canada. Some of these aspects are that:

- pests became established in agriculture when the natural environment was cleared to grow food;
- a handful of farmers produce enough food for us and for export;
- pests can destroy much of our food supply if they are not controlled;
- various methods, including pesticides, are used to control pests;
- the controversy over beneficial vs. harmful effects of pesticides to the environment and our health rages on;
- the federal and provincial governments have control over which pesticides may be used in this country or province;
- a managerial approach to pest control, namely an integration of all existing methods including pesticides, is being pursued by farmers.

CHAPTER 1

POPULATION BIOLOGY OF PESTS

1.1 INTRODUCTION

GOAL: To understand what a pest is and how an organism becomes a pest.

Every year pests such as weeds, insects and disease-causing fungi account for the loss of nearly one-third of the Canadian harvest. Many of these species are native to Canada but became pests in the agricultural environment when the land use was changed from its natural forested or grassland state to a cultivated state capable of producing food. Other pests were later accidentally introduced into Canada from other countries.

PESTS
1. Weeds
2. Insects
3. Disease-causing fungi

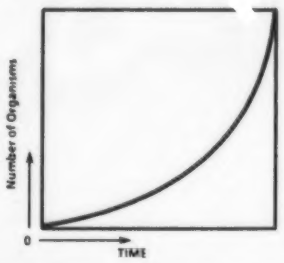
This chapter discusses how an organism becomes a pest, the inter-relationship between living and non-living things in the natural environment and the impact of pests on agriculture.

Canola

1.2 WHAT MAKES AN ORGANISM A PEST

Under ideal conditions a population can increase indefinitely.

In your study of population biology you have learned that a population is a group of organisms capable of interbreeding to increase in number over a period of time. Under ideal conditions that number can increase indefinitely because of the biotic potential of the organism.



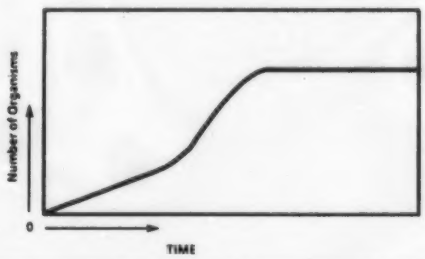
Population growth under ideal conditions would continue to increase.

In reality a population cannot increase indefinitely due to limiting factors.

Biotic potential is the ability of an organism to reproduce at a maximum rate. However, in reality, the size of the population does not increase indefinitely. At some point in time, it begins to be limited by environmental factors, called limiting factors. Such factors can be physical or biological and include space, food, predators, parasites, disease and interspecific and intraspecific competition. The total effect of all these factors is called environmental resistance.

The effect of environmental resistance on the biotic potential of an organism results in an S-shaped curve or population growth curve. According to this curve, the population increases steadily but after a time, a certain number is reached and the population levels off owing to the effect of the limiting factors.

Environmental resistance is the total of the environmental factors that limit biotic potential.



Population growth curve levels off because of the effect of limiting factors.

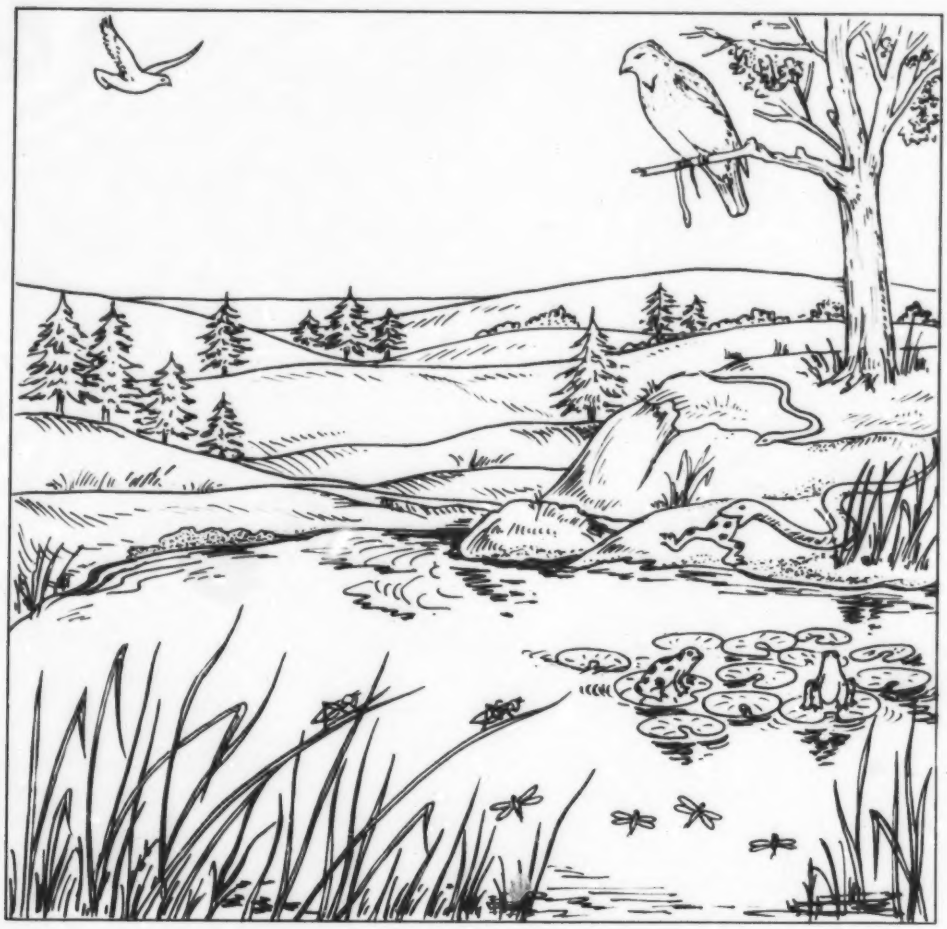
Organisms become pests when the environmental resistance is low.

Organisms become pests in agriculture because the environmental resistance (or the effect of limiting factors) is low. There is usually an abundant supply of space and food; predator, parasite and disease are low and competition is non-existent. This allows the biotic potential to attain a high level. With time, the size of the population becomes so high that it begins to do enough damage to a food crop to warrant control measures. At this stage the organism is treated as a pest.

1.3 THE NATURAL ENVIRONMENT

At one time this entire country was in a natural state.

One can assume that the land and water of this entire country were in a natural state at one time. Climax communities (the final stage of evolution of a community) of forests, lakes and open grasslands had been established and populations of animals, plants, insects, microorganisms and man coexisted in the natural environment. The Indians lived by hunting wildlife, fishing, and eating wild fruits and berries. In other words, they lived off the land. But being so dependent on nature, they were required to



Inter-relationship between several animal species in a natural aquatic environment. The dragonfly is food for the frog, which is food for the snake, which in turn is food for the bird.

move from place to place in search of their livelihood. Feeding themselves and their families would have been a full time chore in those days.

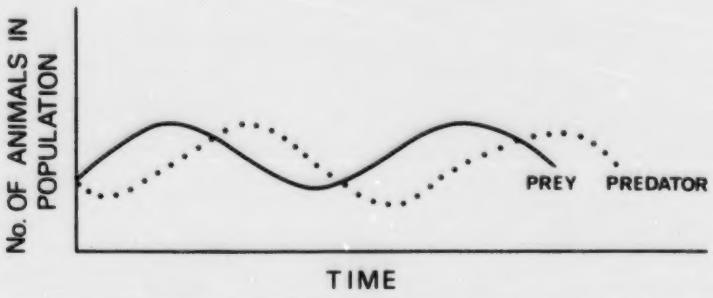
Nevertheless, the environment was in a natural state. There were no cars or factories to pollute the air and water, and no human settlements or agriculture to alter the environment. There were a few nuisance insects such as mosquitoes, but there were really no pests. Nature would have been kept in balance through the inter-relationships of all living and non-living things.

In a natural state hundreds of species would have coexisted.

Theoretically, in a natural environment, hundreds of species of animals, plants, insects, and microorganisms coexist, interacting in some particular way with each other. In your study of ecology, you learned about predation where one kind of insect may keep one or a few other insect species in check by feeding off them. A drop in numbers of the food species (prey) would cause a drop in numbers of the feeding species (predator). Conversely, an increase in the food species would cause an increase in the number of feeding species. Similarly, parasitism can be a limiting factor. Some microorganisms (parasite) may live inside the body of an insect or animal (host) and eventually kill that host. This in turn leads to the death of the parasite.

Each species is kept in check by others for the benefit of all.

By this interaction, populations of each species in the natural environment will often fluctuate up and down cyclically but generally none will be eliminated completely. Each species is kept in check by one or several others for the benefit of all. Predators and prey, parasites and hosts would have coexisted.



Cyclical fluctuation in populations of predator and prey in a natural environment.

1.4 THE AGRICULTURAL ENVIRONMENT AND PESTS

Settlers planted their own crops and reared animals for food.

When the first Europeans came to Canada, they did not rely entirely on nature for their survival. Instead, they planted their own crops and reared domesticated animals for food. Thus, agriculture was introduced into Canada. The early settlers, unlike the Indians, did not have to move about from place to place. Thus, settlements were formed.

Fields of cereals in the agricultural areas of western Canada. The prairie grassland was converted from a natural environment to an agricultural environment nearly a century ago to grow food

Natural land was cleared to establish settlements and agriculture.

The advent of the first settlers brought about a change in the environment. A portion of the forested and grassland areas was cleared to establish human settlements and agriculture. Food crops such as fruits, vegetables and cereals were grown in the agricultural areas; houses were built in towns and cities.

In the new environment, organisms with no predator or parasite became pests.

As more settlers arrived agriculture expanded. Most native organisms in the cleared areas could not survive the change in habitat and died. However, in some cases, animals, plants, insects and microorganisms adapted to the new environment. Prey and predator, host and parasite re-established their relationships in the new environment. In other cases, those organisms which had no predator or parasite became pests; plant pests competed with the crop for space, moisture, nutrients and sunlight, and insects and diseases competed directly with man for his food. Initially the number of pests were very few. But as more settlers came to Canada, they accidentally introduced a number of pests from their homelands.

The city of Edmonton – a modification of the natural environment to form a human settlement.

Canada thistle (white areas), a problem weed in prairie cropland, was introduced accidentally from Europe.

1.5 HOW PESTS PROSPER AND THEIR EFFECT ON AGRICULTURE

Pests prosper because weather conditions or growing conditions are favorable for them to multiply and proliferate, or the predator or parasite of these pests may be absent or too few in number to have a significant impact.

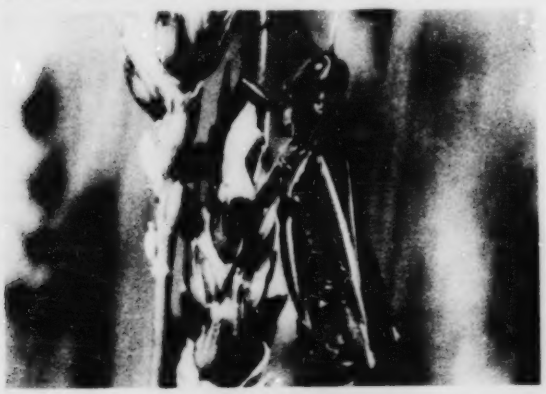
Weeds prosper by adapting to the cultivated land and by growing in the spring at the same time as the crop seed was sown. The weeds compete with the young crop seedlings for nutrients, moisture, space and sunlight. If the weeds are not controlled they can eventually choke out and kill crop plants. Thus the production of the crop would be reduced.

Weeds competing with the crop can reduce production.

It is estimated that if weeds are not taken out of a wheat field, total production for that field can drop by 30 percent. For other crops, the loss can be up to 100 percent. It is estimated that there are over four hundred species of weeds in Alberta. Some of the major ones are wild oats, Canada thistle, scentless chamomile, leafy spurge, stinkweed and toadflax.

Insect pests are usually present in a field crop but flare up only if weather conditions are favorable. Wet or dry conditions favor particular insects depending on their life cycles. If a portion of the life cycle is spent in the soil, dry conditions will favor development while wet weather will hamper it. For example, grasshopper eggs are laid in the soil in the fall of each year. Dry conditions in the spring will foster the hatch and emergence of young grasshoppers. But a wet spring will lessen the hatch and emergence of young grasshoppers, and it will foster the impact of natural parasites among the insects.

When weather conditions are favorable, insect infestations can occur.



Two-striped grasshopper adult.

This dual assault, that is the combination of wet weather and parasites, can play a major role in controlling an infestation. Dry conditions will also favor cutworm outbreaks, another major agricultural insect pest in Alberta, but will hamper mosquito outbreaks as they rely on moisture in order to hatch and grow.

There are an estimated 2,500 species of insects in Alberta, about 250 of which are pests that attack our food supply. Some of these are the grasshopper, cutworms, bertha armyworm, Colorado potato beetle, fleabeetle and wireworm.

There are an estimated 2,500 species of insects in Alberta.

1.6 SUMMARY

At one time the environment in its natural state was kept in balance through the inter-relationships of living and non-living things. Settlers arrived and cleared the land to produce food. But this upset the natural balance, leaving the way for organisms to establish themselves as pests that competed with the cultivated crops.

1.7 QUESTIONS

1. What is a pest?
2. Name some weeds in agricultural land in Alberta.
3. Why do certain pests thrive in the agricultural environment?
4. What limiting factors affect the size of a grasshopper population to cause or prevent an infestation of economic proportions in a food crop such as wheat?

1.8 SUGGESTED CLASS ACTIVITIES

1. View the film "Pest Wars" (30 minutes) obtainable from Alberta Agriculture (403)427-2121 in Edmonton.
2. Obtain a copy of "Backyard Pest Management" (Alberta Agriculture, Agdex 605-2) from Alberta Agriculture. Identify some of the insects that are pests in your home vegetable garden.

CHAPTER 2

AGRICULTURE AND FOOD PRODUCTION IN CANADA

2.1 INTRODUCTION

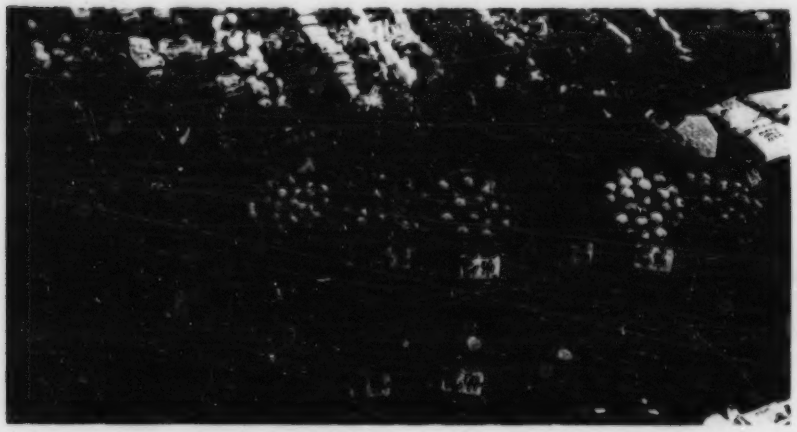
GOAL: To understand the developments that led to Canada's success as a food producer.

In your study of the human population and agriculture in Biology 20 you learned of many advances in both technology and agriculture. This chapter further expands on the developments of agriculture that led to Canada's success as a food producer.

2.2 FOOD PRODUCTION IN CANADA

A small percentage of the population grows most of our food.

Our supermarkets usually carry an impressive array of fruits, vegetables, meats, canned and frozen foods and groceries, most of which are of high quality and nutritive value. These foods in their variety and abundance are the product of agriculture. Much of this food is grown in Canada by farmers. About four percent of the population in Canada is engaged in agriculture. But their total production is high enough to allow Canada to satisfy its own consumer needs and to trade the surplus for other needed goods from other countries. Today, Canada is one of four nations of the world that exports more food than it imports. The other three countries are the United States, Australia and Argentina.



Top quality fruits and vegetables in a Canadian supermarket.

Canadians have a thriving agricultural industry.

Canada is one of the most fortunate nations in the world. It has a wide range of landscapes, a climate that permits a variety of activities, a fertile soil, and a people who have responded to this natural heritage in an appreciative and productive manner. Through conscientiousness and hard work, Canadians have succeeded in developing a thriving agricultural industry.

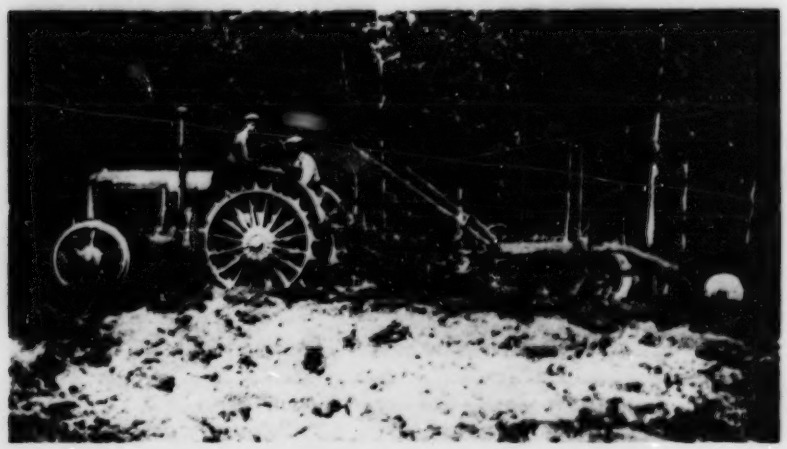
A pioneer farmer.

In the early days agriculture was difficult and labor intensive.

Few means were available to combat pests.

Before 1940, one farmer produced enough food for seven people.

Agriculture in the early pioneer days was difficult and labor intensive. Farm machinery was unsophisticated and much of the work had to be done by manual labor. Thus, early settlers worked long hours to till the soil, sow the seeds, control the pests, and harvest the crops. Farms were small and operated as family units. The amount of food produced per acre was low compared with today, for despite the farmer's endless toil, crop losses were high. Natural elements such as frost, drought or heavy rainfall, and pests of both native and foreign origin usually took their toll. To combat the pests, of which there were not as many as are present today, farmers used whatever means were available at the time. These included cultivation, crop rotation, and a few, very dangerous pesticides, such as arsenic and mercury. Other than these, pest control was largely left to nature. Prior to 1940, one Canadian farmer was producing enough food to feed only about seven people.



Farm machinery in the early days of agriculture in Canada.

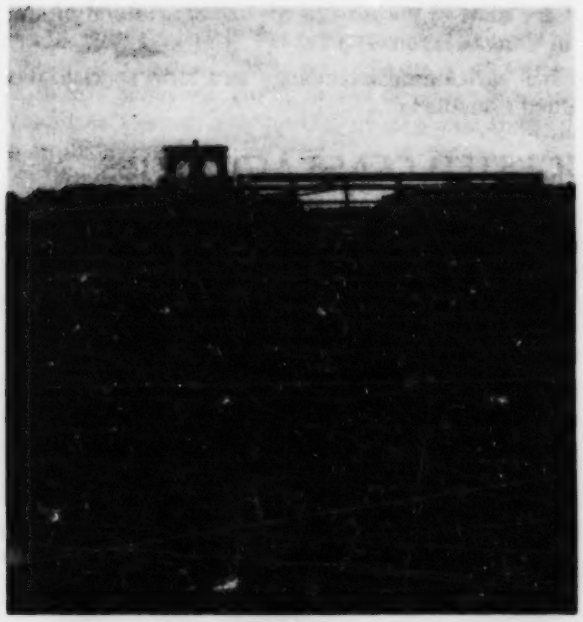
Technological changes in science and agriculture brought dramatic change.

The years following the Second World War saw a dramatic change in agricultural production brought about by technological advances in science and agriculture. Farm machinery, fertilizers

and crop varieties were improved, and a wide range of new and effective pesticides were developed.

Farmers specialized depending on the climate and soil.

Farmers in different areas of Canada soon began to specialize in the types of crops they grew depending on the climate or soil. For example, in British Columbia, farmers specialized mainly in fruits and vegetables; on the prairies, they concentrated on grains and cattle; in central Canada, they found advantages in specializing in fruits, vegetables and dairy farming. In the Maritime provinces, Nova Scotia's farmers became famous for apples, and in Prince Edward Island and New Brunswick, the potato has given these provinces international recognition.



An Alberta farmer harvesting grain crop with modern farm machinery.

2.3 AGRICULTURE IN CANADA TODAY

The development and implementation of new technological advances have led to an increase in the size of farms and in food production while there has been a reduction in the number of farmers. The improvements over the years have enabled large areas of land to be cultivated and seeded within a short period of time, fertilizers and pesticides to be applied fairly rapidly, and crops to be harvested and stored before frost arrived. Today, one Canadian farmer grows enough food to feed 70 people. But this specialization and change in the natural environment, plus the accidental introduction of foreign species, has caused the problem of pest control to gradually increase. New technology was needed to manage the situation. This topic will be discussed more thoroughly in Chapter 5.

REASONS FOR EFFICIENT AGRICULTURAL PRODUCTION

- Improvements in farm machinery, fertilizers and crop varieties.
- Development of new, effective pesticides.
- Specialization of farms in different areas of the country.

2.4 QUESTIONS

1. How many people can one Canadian farmer produce enough food for today?
2. What are some of the reasons for low agricultural production in Canada before 1940?
3. How has agricultural technology and farm specialization benefited Canadians?

2.5 SUGGESTED CLASS ACTIVITIES

1. Obtain several full-page supermarket newspaper advertisements which feature a variety of foods. Identify certain food items such as strawberries, tomatoes, flour, etc. and speculate as to which province in Canada they may have been grown. Also, speculate as to which area in the United States they could have been imported from.
2. Obtain a current issue of the Country Guide magazine from your library. Identify some animals found on the farm and indicate some food products that may be obtained from them.

2.6 REFERENCES

1. YESTERDAY – A Pictorial History of Agriculture in Alberta, 1980. Alberta Women's Institutes.
2. PESTICIDES, AGRICULTURE, AND THE ENVIRONMENT, 1981. Agricultural Institute of Canada.
3. FARM FACTS FOR CITY FOLKS, 1983. Canadian Agricultural Chemicals Association.

COMMENT ON AGRICULTURE

In the space of a century, Canadian farmers have increased their output nearly 25 fold. One hundred years ago, when 90 percent of the population lived on the land, a farm worker produced enough food for three persons. Today's farm worker produces enough food for 71 persons. Agriculture more than keeps pace with industrial modernization; it leads the way. Productivity per hour has increased at twice the rate of other industries.

Because of agriculture we can feed ourselves and have plenty to spare for export. Only 4 percent of the Canadian population is needed to work the land today.

If we still had to farm the way our grandparents did, we would need a labor force about seven times the size of the present one. A third of our urban labor force would have to give up their jobs in the city and return to the farm. We would need more than twice as much cropland to match current production levels. It would be an impossible task. Our economy could not survive the loss of goods and services and we do not have vast untapped areas of potential farmland. There is a lot more to agriculture than just farming – all told the agriculture sector generates about 40 percent of all economic activity in Canada. Dozens of industries supply the farmer who grows the food. Canadian farmers spend billions of dollars on materials and services for production. This expenditure results in thousands of jobs in the steel, rubber, automotive and machinery industries, plus seed, feed, fuel, fertilizers and similar supportive services for agriculture.

A whole sector of the economy is made up of secondary processors and manufacturers who rely on agriculture to supply them with raw materials. The food and beverage industry accounts for almost 40 percent of the value of all goods shipped by Alberta's manufacturers.

An estimated million and a half Canadians who work at grading, storing, processing, packaging, transporting, selling and preparing food count on the farmer for their livelihood. With their families, nearly five million Canadians depend on agriculture for their economic survival.

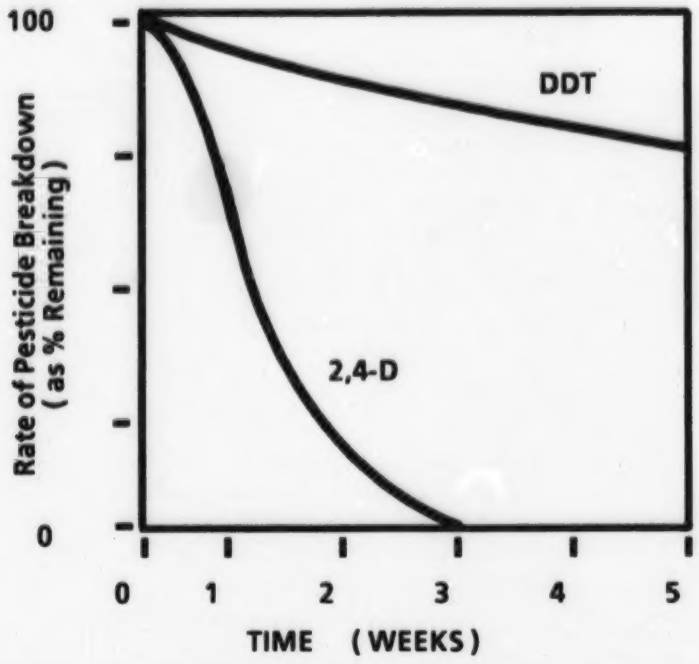
CHAPTER 3

THE PESTICIDE CONTROVERSY

3.1 INTRODUCTION

GOAL: To understand both sides of the pesticide controversy.

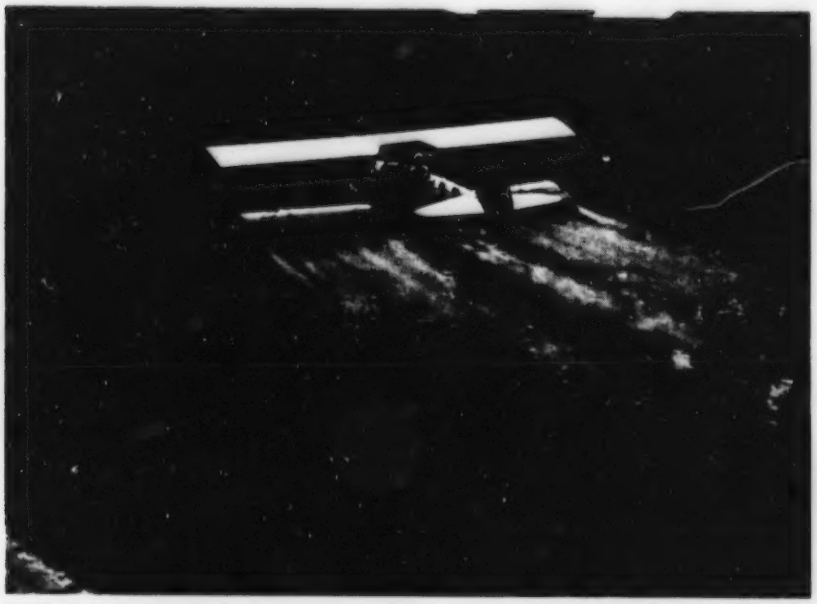
The discovery of modern pesticides occurred just before the second world war. The insecticides DDT and malathion, and the herbicide 2,4-D were among the first to be developed. DDT was not easily degraded in the environment, a property that was considered an advantage at that time.



DDT was very slowly degraded in the environment whereas most pesticides, e.g., 2,4-D in use today, degrade fairly rapidly.

Because of this persistence, a single treatment of a pest-infested area with the insecticide would control insects for several months. Thus, the chemical was used quite frequently to control malaria-carrying mosquitoes during and after the war. However, this persistent nature of DDT and a few other pesticides was later found to have an undesirable effect on some non-pest species.

This chapter reviews the role of these persistent pesticides in saving human lives and considers the effects these chemicals have had on wildlife populations.



Trees being sprayed with DDT against malaria-carrying mosquitoes during the second world war.

3.2 PESTICIDES, HUMAN HEALTH AND WILDLIFE

Shortly after the insecticidal properties of DDT were discovered in 1939, the Second World War broke out. The chemical was soon put to use to protect human lives by controlling the human louse that carried the disease typhus, which had been rampant during the First World War and was a major factor in the death of many soldiers.

DDT was effective in reducing human diseases.

The effectiveness of DDT against a wide range of insects led to the reduction of many other human diseases as well. Foremost among these were the plague, yellow fever and most importantly, malaria. Its effectiveness against the malaria-carrying Anopheles mosquito was so outstanding that global eradication of this disease was proposed by the World Health Organization in 1955.

Treatment of mosquito breeding areas with DDT resulted in the eradication of the disease by 1972 in about 40 countries, and a drastic reduction in an additional 80 countries. In India alone, the incidence of malaria decreased from 100,000,000 cases annually in 1933, before DDT was discovered, to just over 100,000 cases in 1966, and annual number of deaths from malaria was reduced from 750,000 to just over 1000.

Following the Second World War, pesticides were used not only to combat human diseases but also to control pests that were problems to agriculture. The effect that some of these might have on wildlife was not considered. Only their potential as pest control agents was recognized.

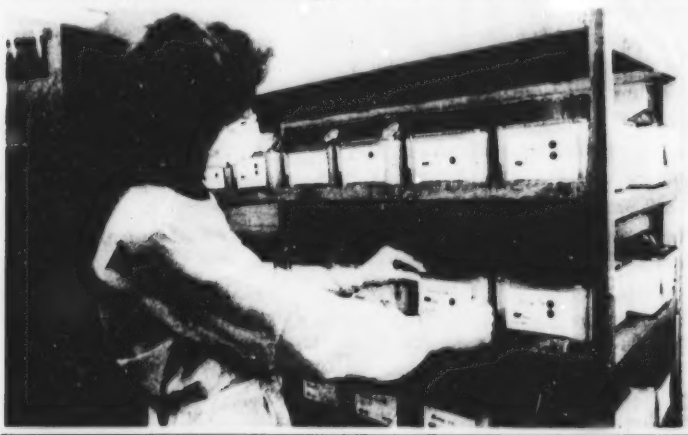
CONTROL OF MALARIA-CARRYING MOSQUITOES IN CEYLON (SRI LANKA) WITH DDT	
YEAR	NUMBER OF CASES OF MALARIA
1950	2,000,000
1950's	DDT eradication program begun
1962	31
1963	17
1964	DDT use stopped
1964	150
1965	308
1966	499
1967	3,466
1968	1,000,000
1969	DDT eradication program resumed

Thirteen years after initiation of a mosquito eradication program in Ceylon, cases of malaria dropped from 2 million per year to 17. Ceylon discontinued using DDT and within five years, cases of malaria climbed to 1 million. The use of DDT was reinstated in 1968.

In the mid 1950s the problem of DDT's persistence arose.

After being in use for about 10 years, in the mid 1950s, concern arose over DDT's persistence in the environment. The common perception of pesticides changed from one of disease-preventer to one of disease-inducer. Some people now question the general use of pesticides, suggesting that they may contribute to an increase in human cancer.

Because pesticides are used to kill pests in food crops, there is always the concern that these chemicals may enter the human body to cause long-term health problems, especially cancer. The average person consumes a total of less than one part per billion of pesticide in his/her food per day, an extremely low amount. Yet fears about the cancer-causing potential of this low level still exists.



Mice are often used in tests to determine the cancer-causing potential of substances proposed for direct addition to foods, or present in foods, or as indirect or incidental additives. Shown here are cages of mice used in an experiment to test the effects of lead that may be found in trace quantities in foods as indirect additives.

This question of the causes of cancer in the general population was recently addressed by the National Academy of Sciences in the United States. In 1983 the academy published a report which reviewed our exposure to various elements in the environment and their potential to cause cancer. The report indicated that very low levels of some persistent pesticides may be found in water and foods in Canada and the U.S., but that they do not contribute to the risk of cancer in humans because they are present in such small amounts. The report listed such pesticides as DDT, kepone, toxaphene, hexachlorobenzene and heptachlor that may be found in the environment.

PESTICIDES FOUND IN WATER AND FOOD
DDT kepone toxaphene hexachlorobenzene heptachlor

The use of these pesticides ceased several years ago in both countries and their levels in the environment are rapidly decreasing. It is expected that the levels will be down to near zero in another five years. However, the report recommended that as long as these chemicals are in the environment, they should be monitored closely even though the amounts present in the average North American diet do not make a major contribution to the overall risk of cancer.

The use of persistent chemicals ceased several years ago.

Fat soluble pesticides built up in the food chain.

Problems were also reported in wildlife populations. This situation was made known in the book **Silent Spring** by Rachel Carson. The problem with some of these pesticides was their long persistence in the environment, and their ability to accumulate in the fat of insects, fish, mammals, birds and man. DDT was the most notable among this group of pesticides. Because such chemicals are fat soluble, they are not readily broken down by the body or by microorganisms, sunlight or other physical factors. As you learned in your biology 20 course, each time an organism feeds on another living thing there is a transfer of materials and potential energy. The transfer in a series makes up the food chain. This is how the fat soluble pesticides build up successively along the food chain.

Fish and fish-eating birds at the top of this aquatic food chain accumulated high amounts of DDT that affected their populations. DDT was present in the water and was taken up by insects, which were eaten by fish which were in turn eaten by birds.

The animals at the top of the food chain, second and third order consumers, such as fish, predatory birds and top level carnivores such as wolves, could therefore accumulate a high concentration of these pesticides in their fat.

This accumulation is easily seen in predatory birds such as hawks and eagles. Enough pesticide was accumulated to cause thinning of their egg shells. This caused their eggs to break too easily and their populations declined.

Accumulation of fat soluble pesticides caused egg thinning in birds.

Once these problems were recognized, there was a drastic change in the types of pesticides developed. Degradable, water-soluble and less persistent pesticides appeared. Some of these, malathion for example, had already been discovered during the Second World War and had been used in malaria prevention campaigns.

Degradable, water-soluble and less persistent pesticides were developed.

PESTICIDE	PERSISTENCE (weeks)
Carbaryl	1
Malathion	2
Diazinon	2
2,4-D	3
MCPA	4

Most pesticides in use today degrade fairly rapidly in the environment.

After the war, they were also used to control insects in farmers' crops. No reproductive problems with birds or other animals were ever reported from their use. Today, nearly all the pesticides in common use break down fairly rapidly to non-toxic byproducts which are then used as nutrients by microorganisms. Modern pesticides persist from about one to four weeks in the environment. Most are not fat-soluble and, therefore, cannot accumulate in animals at the top of the food chain. Their situation is in complete contrast to the early, long-lasting pesticides.

Today's pesticides breakdown fairly rapidly into non-toxic byproducts.

However, as long as pesticides are being released into the agricultural environment, there should be no complacency. Despite the short life of these pesticides, constant vigilance must be maintained. Potential problem areas must be envisaged and studied, and constant monitoring of pesticides in the natural environment must be continued. In this way, any pesticide-related problems that arise will be detected and attempts made to resolve them.

Constant monitoring will help detect any problems and to resolve them.

Alberta lakes, rivers and fish are monitored for possible contamination by pesticides.

3.3 PESTICIDES IN THE ENVIRONMENT

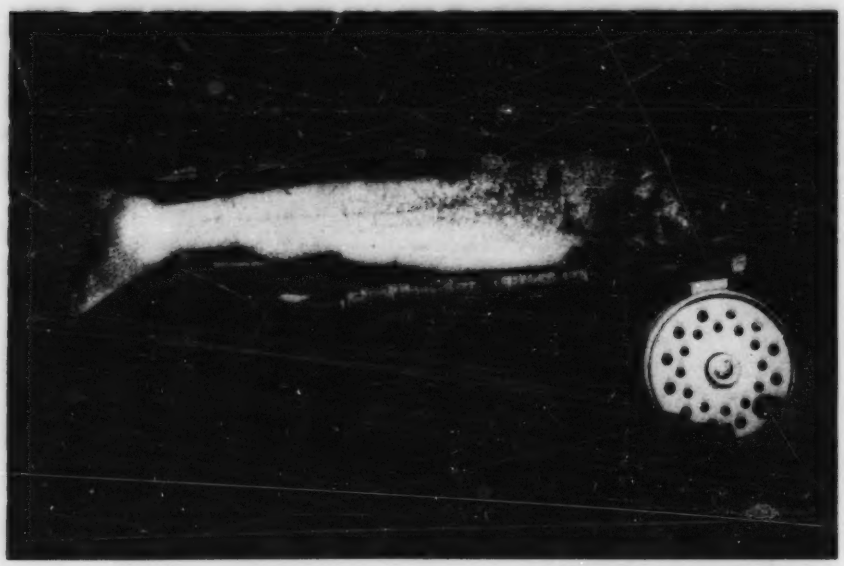
Monitoring studies have been done in the prairies.

Three monitoring studies have been done to determine the levels of pesticides contained in the prairie environment. The first one was done over the period from 1971 to 1977. In this study 23 pesticides were monitored in surface waters throughout the prairie provinces.

The results indicated that 19 pesticides banned several years previously (including DDT, aldrin, dieldrin, heptachlor and endrin) were not in evidence. Many of the pesticides in current use also were not found. But four of the pesticides that were in use at the time the study was done were found in parts per trillion levels in the heaviest agricultural areas of the prairies, and only during the late summer months. These were the herbicides 2,4-D, 2,4,5-T, 2,4-DP and the insecticide lindane. The 2,4-D in the water was caused by vapor drift because a volatile formulation of the herbicide was in use at the time. Since then, this formulation has been removed from use. 2,4,5-T is no longer produced by the manufacturer. Lindane and 2,4-DP are currently used in agriculture in Alberta in very small amounts.

Another study published in 1980 found that the herbicide 2,4-D did not accumulate in river sediment in agricultural areas where the herbicide was most heavily used.

A more recent study by the Alberta Environmental Centre in Vegreville monitored the amount of pesticides in fish from Alberta's lakes and rivers. Only the chemical lindane was found, and only at extremely low levels. According to this report, these levels do not pose a threat either to the health of fish or its consumers.



Photograph by D. Belcher (Pazder Graphics)

Lindane does not accumulate in fish tissues.

Constant monitoring of several species of Alberta birds indicates that parts per million levels of DDT may still be found in their fat. Since many of the birds analyzed are migratory in nature, it is suspected they picked up this DDT in countries where the chemical is still in use. Over the years, there has been a drastic decline in the DDT level with no sign that it is still endangering bird populations.

Monitoring indicates no danger to Alberta birds from DDT in other countries.

WHAT IS A PART PER TRILLION?

In the area of pesticide monitoring, advances in instrumentation technology have made great leaps over the last 10 years. At one time, the amount of pesticide in the environment was measured in parts per million (ppm). Today, these chemicals can be measured in parts per billion (ppb), parts per trillion (ppt) or even parts per quadrillion (ppq).

One part per million is equivalent to 1 milligram (mg) of a pesticide in 1 kilogram (kg) of water, or sediment, or fish, etc. depending on what is being analyzed. One part per billion is 1 mg in 1,000 kg, one part per trillion is 1 mg in 1,000,000 kg. One ppt, the concentration level at which pesticides are present in the environment, would be equivalent to grinding up and spreading ten **grains** of table salt evenly over an entire football field – an inconceivably low concentration.

Pesticides can be detected in extremely low levels today.

Because extremely low levels of pesticide can be detected, scientists can more readily determine if the environment is being contaminated. Although present knowledge indicates that the levels found today are not hazardous, anything that has the potential to affect the environment is watched carefully.

3.4 SUMMARY

The development of modern pesticides began just before the Second World War and were used to control pests that carried deadly human diseases such as typhus, the plague, yellow fever, and malaria. After the war these pesticides were also used extensively to control pests in agriculture and were in part responsible for the abundance of food produced by Canadian farmers. However, some of the pesticides were persistent in the natural environment and accumulated in high levels in fish and some predatory birds such as eagles, hawks, and falcons. The realization of the potential for persistent pesticides to affect bird populations brought about a drastic change in the new types of pesticides. Today most pesticides used break down fairly rapidly in the environment and therefore do not accumulate in the food chain.

3.5 QUESTIONS

1. What are some of the human diseases conquered by DDT?
2. Name four pesticides used today that degrade fairly rapidly in the environment.
3. By what mechanism did DDT affect bird populations?
4. In your opinion, what are three major causes of death in people over 45 years of age in Canada and the U.S.?

3.6 SUGGESTED CLASS ACTIVITIES

1. View the short film "From Soil to Table" (15 minutes) available from the film library of Alberta Agriculture in Edmonton.
2. Suggest that your teacher arrange a visit, if possible, to a private or government laboratory that does pesticide analysis. Many of these labs are located in Edmonton, Calgary, Olds, Fairview, Lethbridge, and Vegreville.

3.7 REFERENCES

1. McEwen, F.L. and G.R. Stephenson (1979). **The Use and Significance of Pesticides in the Environment.** John Wiley & Sons, Toronto.
2. National Research Council (1982). **Diet, Nutrition and Cancer.** National Academy Press. Washington.

CHAPTER 4

GOVERNMENT CONTROL OVER PESTICIDES

4.1 INTRODUCTION

GOAL: To understand the government's involvement in the management of pesticides

Your Biology 20 textbook discusses how pesticides can be very beneficial for many reasons, yet in some ways they may be harmful. This chapter explains how the federal and provincial governments of Canada ensure that the potential hazards of pesticides are known, that pesticides are used safely, and that consumers are not exposed to significant amounts of pesticides in their foods.

Food products, including meat, are regularly checked for any possible presence of pesticides.

Humans may be exposed to pesticides in two major ways: by direct contact when using a chemical, and by the consumption of pesticide-treated food crops. Although most pesticides degrade fairly rapidly and may not be present in our foods at the time of consumption, it is imperative that the potential hazards of the chemicals be known.

By knowing potential pesticide hazards, measures can be taken to prevent exposure.

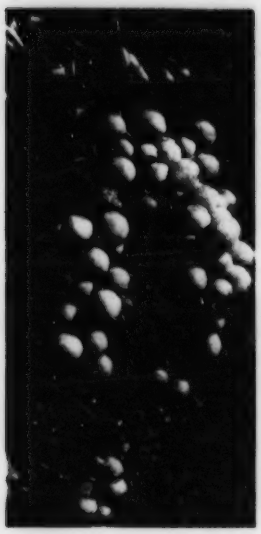
Pesticide exposure may occur during the spraying of the chemical.

By knowing this potential, appropriate measures can be taken either to disallow use of a pesticide, or to allow use in such a way that the user or the consumer is not exposed to significant amounts of the chemical. By not knowing this potential, appropriate measures to prevent exposure may not be taken and severe problems to human health may occur.

4.2 PESTICIDE APPROVAL

The federal government must approve all pesticides used in Canada.

The Government of Canada must approve of a pesticide before it can be used in this country. Once federal approval is given, a pesticide may or may not be used in a province depending on the pest problems of that province. For example, the pest problems in the prairie provinces where mainly grain is grown are different from those in certain areas of British Columbia or Ontario where a wide variety of fruits and vegetables are grown. Thus, the prairie provinces may use certain pesticides which are not necessarily used in fruit-growing areas of other provinces.



Grapes from British Columbia

Prior to approval being given by the federal government, an application must be made by the manufacturer seeking to get its product approved for use in Canada. These manufacturers are usually from other countries such as the United States, England, Holland, France, and Japan. Canada does not manufacture pesticides.

Manufacturers submit an application and all tests and results to the government for approval.

THE APPROVAL PROCESS FOR PESTICIDES

Pesticide Manufacturer

|

Tests

|

Results

|

Application for Approval

|

Federal Government

|

Approval

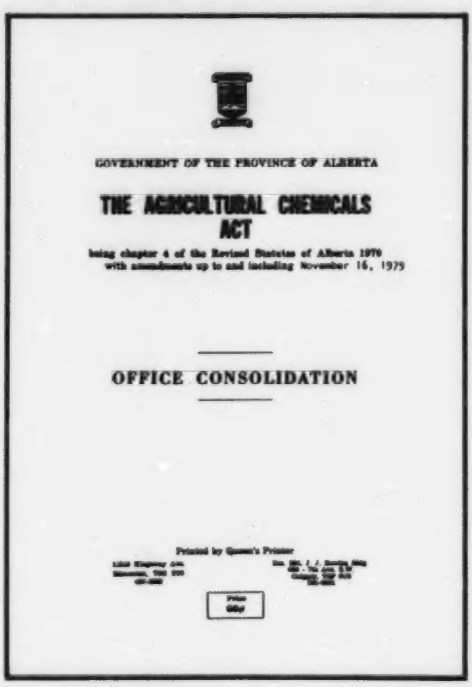
Application for approval must be accompanied by the results of extensive tests carried out on the pesticide by the manufacturer. Such tests are designed to investigate three major areas: (1) the effectiveness of the pesticide on the pest or pests; (2) the environmental problems that the pesticide is likely to cause; and (3) the health problems that may be incurred by the pesticide user and the general public. The results of these tests are submitted by the manufacturer to the federal government for close scrutiny.

If the tests indicate that a pesticide may cause cancer, miscarriages, birth defects, or mutation, or that it is very persistent in the environment and may accumulate in birds and other life forms, the federal government may not give approval to the pesticide.

If the pesticide is no threat to the environment, humans or wildlife it may be approved.

If the results of the tests indicate that the pesticide poses no threat to the environment, or to the health of the pesticide user, or to the general public, the pesticide may be approved by the federal government. The manufacturer may then sell it in Canada.

Each province has its own control over the sale and use of the pesticides approved by the federal government. In Alberta, wholesalers and most retailers of pesticides have to acquire a license from the provincial government to sell pesticides. Commercial pesticide users, except farmers, have to be trained and have to pass an examination before they can receive a licence to spray pesticides. They acquire much of their information about pesticides from publications, seminars, pamphlets, and training courses organized by provincial government departments. Farmers and homeowners are not required to be trained in any way before they use a pesticide.



GOVERNMENT OF THE PROVINCE OF ALBERTA

THE AGRICULTURAL CHEMICALS ACT

being chapter 4 of the Revised Statutes of Alberta 1970 with amendments up to and including November 16, 1979

OFFICE CONSOLIDATION

Printed by Queen's Printer

The Agricultural Chemicals Act is the provincial law that regulates the sale, use and handling of pesticides in Alberta.

Only about 100 of the nearly 500 pesticides approved by the federal government are used in Alberta.

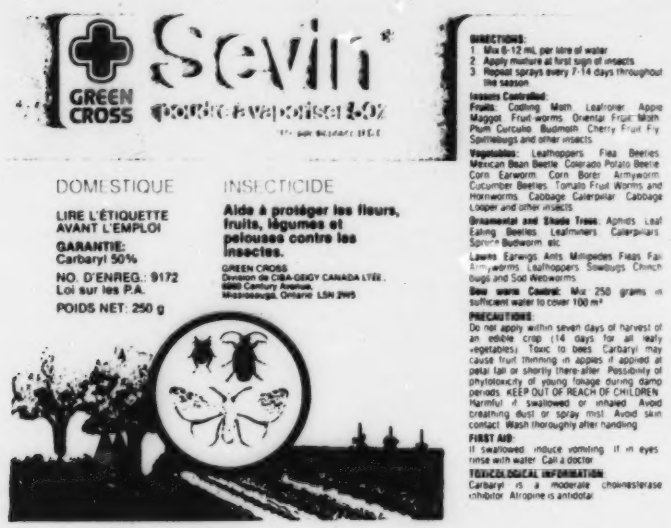
Once a pesticide is purchased by a customer, government control over the pesticide ends and it is up to the buyer to use the chemical properly. The label directions on the pesticide must be read carefully and followed exactly. This includes using the right pesticide for the right pest. If used other than as directed, the pesticide may pose some risk to the environment or to human health. Therefore, all pesticides must be used in accordance with the label instructions.

When a pesticide is purchased, it is up to the buyer to use it properly.

4.3 THE PESTICIDE LABEL

The pesticide label contains very important information about a pesticide product. In far too many cases, the label is not read before the consumer uses the pesticide. Consequently, the amount applied can be too high resulting in fruit or vegetable contamination. In such cases, valuable produce may have to be discarded. In other cases, people or domestic animals have become ill because the proper precautions have not been followed.

A pesticide label contains very important information.


GREEN CROSS
Sevin
DOMESTIQUE
INSECTICIDE
LIRE L'ÉTIQUETTE AVANT L'EMPLOI
GARANTIE: Carbaryl 50%
NO. D'ENREG.: 9172
Loi sur les P.A.
POIDS NET: 250 g
Aide à protéger les fleurs, fruits, légumes et pelouses contre les insectes.
GREEN CROSS
DIRECTIONS:
1 Mix 6-12 mL per litre of water
2 Apply mixture at first sign of insects
3 Repeat sprays every 7-14 days throughout the season
Insects Controlled:
Fruits: Codling Moth Leafroller Apple Maggot Fruit worms Oriental Fruit Moth Plum Curculio Budmoth Cherry Fruit Fly Spittlebugs and other insects
Vegetables: Leafhoppers Flea Beetles Mexican Bean Beetle Colorado Potato Beetle Corn Earworm Corn Borer Armyworm Cucumber Beetles Tomato Fruit Worms and Hornworms Cabbage Caterpillar Cabbage Looper and other insects
Ornamental and Shade Trees: Aphids Leaf Eating Beetles Leafminers Caterpillars Spruce Budworm etc
Lawns Earwigs Ants Millipedes Fleas Fall Armyworms Leafhoppers Sowbugs Chinch bugs and Sod Webworms
Sow worm Control: Mix 250 grams in sufficient water to cover 100 m²
PRECAUTIONS:
Do not apply within seven days of harvest of an edible crop (14 days for all leafy vegetables) Toxic to bees Carbaryl may cause fruit thinning in apples if applied at petal fall or shortly there-after Possibility of phytotoxicity of young foliage during damp periods KEEP OUT OF REACH OF CHILDREN Harmful if swallowed or inhaled Avoid breathing dust or spray mist Avoid skin contact Wash thoroughly after handling
FIRST AID:
If swallowed induce vomiting If in eyes rinse with water Call a doctor
TOXICOLOGICAL INFORMATION:
Carbaryl is a moderate cholinesterase inhibitor Atropine is antidotal

Permission to reprint requested

The label is present on each pesticide container and contains information on directions for use, precautions to take while using, and first aid measures in case of an accident: ingestion or eye or skin contact.

It is important to recognize that the pesticide label is a legal document. Under the Pest Control Products Act, manufacturers are required to draw up a product's label according to the results of efficacy, toxicity and other tests carried out on the pesticide. The label tells the user to follow the DIRECTIONS to ensure the pesticide is correctly used for maximum pest control.

The directions for use must be carefully followed.

It is very important that the product's DIRECTIONS for use be followed exactly. The amount the label prescribes is usually sufficient to control the pest. If more is used than directed the

control is not better, and some of the pesticide will remain on the crop longer than the safe pre-harvest period. The result: the crop can no longer be consumed and must be discarded.

The precautions tell how to minimize exposure to the pesticide.

The label also provides PRECAUTIONS that must be followed to avoid being exposed to the chemical while using it. Under PRECAUTIONS, certain instructions are given like avoiding fumes or wearing rubber gloves, to cut down on exposure to the chemical. Pre-harvest intervals are also stated to warn the user not to apply the chemical within a certain period before harvesting the crop. The pre-harvest interval allows enough time for the pesticide to break-down in the environment to non-toxic organic molecules. If the directions are followed carefully, the crops will stay healthy and pesticide-free.

Other important information on the label includes the active ingredient, the registration number of the product and the product's manufacturer. In most cases, knowing the active ingredient is the fastest way to check information about treatment for accidental poisoning by the product, should this occur. Sometimes the registration number may be helpful.

To summarize: the pesticide label does contain important information about the product's proper use, the safe pre-harvest period for crops and the precautions needed to avoid human exposure. Although few people have ever been prosecuted, it is actually against the law to use a pesticide in a manner not prescribed on its label. Because of this, it is crucial that the directions be followed very closely.

4.4 MONITORING FOODS FOR PESTICIDES

Health and Welfare Canada monitors the Canadian food supply for pesticides

Health and Welfare Canada is responsible for monitoring the Canadian food supply to determine what amounts of pesticide, if any, are present in our foods. Each year, both domestic and imported foodstuffs such as fruits, vegetables, meats, canned and processed foods, are collected from storage warehouses across Canada and checked for pesticides. If any food is found to contain amounts above acceptable levels, the farmer who has produced that food, or the importer, is immediately notified of the violation. New products from that violator are then closely monitored before his/her products get to the retail market. If the acceptable pesticide levels are violated a second time, all those contaminated products are confiscated at the warehouse and destroyed without any payment to the violator. Therefore, farmers are encouraged to follow strict pesticide spraying procedures to avoid contamination of their foodstuffs. Similar regulations exist with regard to pharmaceuticals used on livestock to control disease organisms and/or parasites. Importers also are required to ensure their products meet acceptable standards and to stop importation of contaminated foods.

This procedure is used to extract minute amounts of pesticides from foods for analysis in monitoring programs carried out by the federal Health and Welfare Department.

The results of several years of monitoring foodstuffs for pesticides by Health and Welfare Canada indicate that very few pesticides are ever found in our foods and where present, they are usually found at levels 10 to 1000 times lower than the maximum allowable.

Very few pesticides are ever found in our foods.

In addition to the monitoring done by the federal government, Alberta Agriculture also samples food grown by farmers in this province for pesticides. These results also have been much lower than the acceptable levels.

Alberta Agriculture samples some food grown by farmers for pesticides.

Acceptable levels of pesticides in foodstuffs are usually set by Health and Welfare Canada after studying the results of tests performed on rats and dogs. The animals are fed various doses of a pesticide for two and seven years respectively, and the level considered acceptable is the one where no observable effects are noted. This level is the dose of the pesticide that causes no harm to the rats or dogs as determined by various chemical, biochemical, and pathological examinations. The acceptable level of a pesticide in food for man is then usually set at 100 times lower than the no-observed-effect level, and is the amount of pesticide that a normal healthy person may consume in his/her food or water every day without any health risks. For some pesticides, the acceptable level is zero – that is any measurable trace is unacceptable.

CANADA

OFFICE CONSOLIDATION

Pest Control Products Act

R.S., c. P-10
amended by
1980-81-82, c. 68

Pest Control Products Regulations

C.R.C., c. 1253
amended by

P.C. 1978-3456
P.C. 1979-629
P.C. 1979-630
P.C. 1980-2049
P.C. 1981-675
P.C. 1982-1709

September 1982

CODIFICATION ADMINISTRATIVE

Loi sur les produits antiparasitaires

S.R., c. P-10
modifiée par
1980-81-82, c. 68

Règlement sur les produits antiparasitaires

C.R.C., c. 1253
modifié par

C.P. 1978-3456
C.P. 1979-629
C.P. 1979-630
C.P. 1980-2049
C.P. 1981-675
C.P. 1982-1709

September 1982

The Pest Control Products Act is a federal law which describes the tests that are to be performed on a pesticide before it can be considered for approval.

4.5 SUMMARY

The Government of Canada exercises strict control over the use of pesticides in this country. Extensive tests are required to be done on each pesticide and federal approval must be given before it is used. The federal government also checks our foods to ensure they are free of pesticides. Thus, farmers are cautioned to use the pesticides properly to avoid contamination of our foodstuffs. All pesticide users should follow the instructions on the label to ensure safe and effective use of pesticides.

4.6 QUESTIONS

1. Why is it important to know the potential hazard of a pesticide?
2. What are some of the reasons for the federal government refusing to give approval to a pesticide?
3. What type of information does a pesticide label contain?
4. What is a no-observed-effect level of a pesticide?
5. Discuss the potential problems, to human health and the environment, of doubling or tripling the recommended amount of a pesticide when spraying for pests on food crops.

4.7 SUGGESTED CLASS ACTIVITIES

1. Obtain a pesticide label from the Alberta Agriculture office in your district. Identify the following from the label: Pest Control Product number, trade name, active ingredient and concentration, type of pesticide, manufacturer's name and address.
2. Obtain a copy of the publication **Pesticide Gazette** from the Alberta Agriculture office in your district. Review the various items that appear on the label in the centre page of this publication.

4.8 REFERENCES

1. **The Pesticide Gazette** (1984). Obtainable from the Alberta Agriculture office in your district. Published by the Environmental Resource Centre, 10511 Saskatchewan Drive, Edmonton, AB. T6E 4S1
2. **Pesticides: Something to Think About.**
   Published by the Christian Farmers Federation, 10766 - 97 Street, Edmonton, AB. T5H 2M1.

CHAPTER 5

PEST CONTROL

5.1 INTRODUCTION

GOAL: To understand different methods of pest control.

In chapter 1 you learned what a pest is. The overall impact of the large number of pests in food crops (weeds, insects and disease organisms) is to reduce the amount of food produced. For example, weeds choke out and kill crop plants, insects feed on the young plants, and disease organisms cause rotting of plants or produce. Even after the crops are harvested and stored, insects and diseases can still attack and destroy food. Because nature in some cases can cooperate with pests to cause an infestation and because of the tremendous negative impact of such outbreaks on our food supply, pests must be controlled.

Chapter 3 dealt with the use of DDT and other persistent chemicals, plus degradable, less persistent chemicals such as carbaryl, malathion and 2,4-D to get rid of pests. This method of controlling pests is called chemical control. Two other methods of pest control are cultural and biological control. In most cases, the three methods are used in combination – a technique called integrated pest management. This chapter will cover these four methods of pest control.

METHODS OF PEST CONTROL

1. Chemical
2. Cultural
3. Biological
4. Integrated pest management

5.2 CHEMICAL METHODS OF PEST CONTROL

Chemical methods of weed control are used in a crop to prevent harm to seedlings

Once crop seeds begin to germinate in a field, physical or mechanical methods of controlling pests (such as tillage) are not practical. Destruction of crop seedlings would occur should this method be attempted. Therefore chemical methods or pesticides are used. There are various types of pesticides.

TYPES OF PESTICIDES

Herbicides
Fungicides
Insecticides

Those that kill weeds are called herbicides; those that control crop diseases are fungicides; and those that kill insects are insecticides.

Pesticides are usually produced synthetically in a laboratory by chemists. A few pesticides, however, are obtained from natural sources such as certain plant species. Three of these are pyrethrum, rotenone, and nicotine.

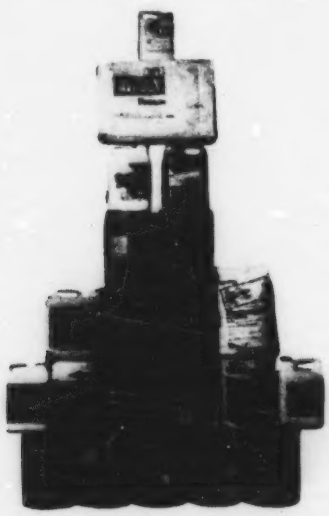
There are synthetic and naturally obtainable pesticides

SOME SYNTHETIC PESTICIDES		
Herbicides	Fungicides	Insecticides
2,4-D	Benomyl	Carbaryl
Dicamba	Carbathiin	Carbofuran
Glyphosate	Captan	Chlorpyrifos
MCPA	Formalin	Diazinon
Triallate	Maneb	Dimethoate
Trifluralin	Thiram	Malathion

HERBICIDES

Herbicides interfere with plant growth functions

Herbicides interfere with plant growth functions. For example, some herbicides attack the leaves of weeds to stop photosynthesis, the energy-producing process in plants. The weeds die from lack of energy. Other herbicides speed up the growth of plant cells beyond normal. These herbicides act like natural plant hormones which cause the cells to grow. When plants are exposed to these herbicides, their cells grow too rapidly, becoming deformed and block the flow of nutrients throughout the plant. Because photosynthesis and plant growth hormones are peculiar to plants and not animals, herbicides usually do not affect animals. Some herbicides are non-specific in that they will kill any green plant. Other herbicides are fairly specific. Some herbicides designed to kill broad-leaved plants will not injure narrow-leaved or grassy plants. Similarily, broad-leaved plants are not killed by herbicides meant for grassy weeds. But, herbicides meant to kill broad-leaved weeds will also kill broad-leaved crops such as beans, mustard and canola.



Some of the herbicides used by Alberta farmers to control weeds in their crops.

FUNGICIDES

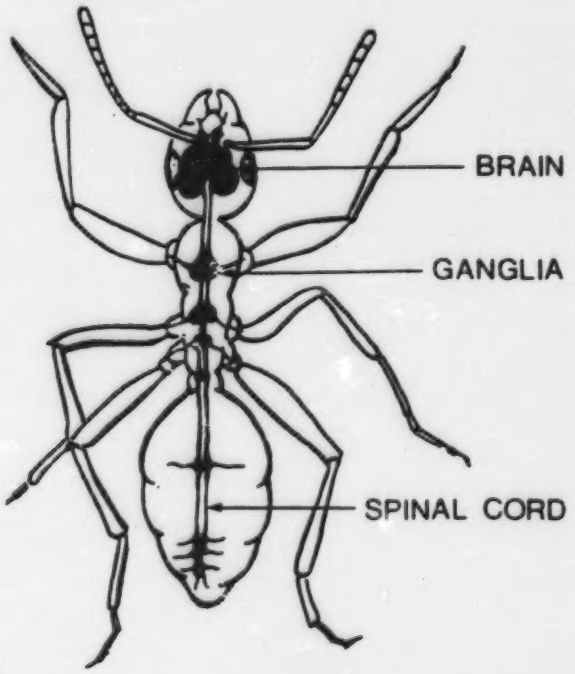
Fungicides are specific and usually do not affect plants or animals

Crop diseases are caused by micro-organisms such as fungi. Fungi survive by carrying out many metabolic functions that are unique compared to those of the evolutionarily more advanced plants or animals. Fungicides act specifically to interrupt these metabolic pathways and usually do not affect plants or animals.

INSECTICIDES

Insecticides can affect man and wildlife

Many insecticides, whether they are synthetic or natural, affect the nervous system of insects. They block the passage of information along the nerves from one part of the body to the other causing uncoordinated body movement, twitching and death. Because the nervous system of man operates in a similar manner to the insect's nervous system, insecticides can affect man and other animals.



Nervous system of the ant.

5.3 RESISTANCE TO CHEMICAL CONTROL

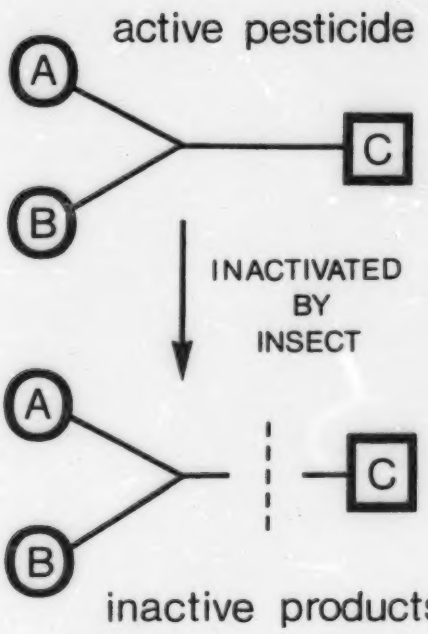
Certain pests can no longer be controlled by certain pesticides. In other words, the pests have become resistant.

The housefly – a pest that quickly becomes resistant to pesticides.

Some pests became resistant to some chemicals

The problem of resistance of pests to pesticides arose in the middle 1950s. It was noticed that when a population (P1) of houseflies was exposed to a certain amount of an insecticide, most individuals would die but a few would survive. The survivors would then multiply to give another population (P2). If this second population is treated with the same amount of the insecticide as before, more individuals than before would survive. If this exposure is continued over several succeeding populations, eventually all the individuals would survive. These individuals have now become resistant to the insecticide.

Resistance is a natural phenomenon in all living things. When an external selection pressure is applied on a population of an organism, most individuals die, but those that can withstand the pressure survive. For example, when a pesticide is applied to a population of houseflies, those that survive are said to be more "fit" than the susceptible ones. These survivors have inherited the ability to resist the effect of the insecticide; that is, the ability or trait to inactivate the insecticide faster than the susceptible individuals.



Resistant pests inactivate pesticides faster than susceptible ones

Resistance in insects was first noticed with respect to DDT. Since then, the phenomenon has been observed with several insecticides, fungicides, and to a lesser extent herbicides, and is a major concern in pest control today. Insects and diseases usually find ways to overcome any pressure that is applied against them. In the case of chemical pesticides the major way is through genetic adaptation, but insects can also adopt various behaviors to avoid being exposed to a pesticide, a predator, or a parasite. For example, some pests cover themselves with soil after a pesticide has been sprayed. When the pesticide disappears from the ground, the pest emerges to continue eating the crop.

New methods of pest control are being considered where resistance to chemicals is high

Pest resistance seems to be more prevalent in the fruit and vegetable growing areas of the country and is, consequently, a relatively minor problem for agriculture in Alberta. Nonetheless, resistance is and will continue to be a major problem in agriculture generally. This situation has been recognized and new methods of pest control are being considered to overcome it.

Pests in fruit and vegetable areas develop resistance quickly because of the frequency with which they have to be controlled

5.4 CULTURAL METHODS OF PEST CONTROL

Cultural control makes use of physical or mechanical means to get rid of pests.

Cultural methods of pest control include using physical or mechanical means to prevent pests from getting established. Foremost among these are tillage, crop rotation, summerfallow, and the use of weed-free seed.

CULTURAL PEST CONTROL METHODS

Tillage
Crop rotation
Summerfallow
Use of weed-free seed
Pest resistant species

TILLAGE

In tillage, the soil surface is disturbed in the fall after crop harvest, or in the spring before seed planting. Weeds, insect eggs and disease organisms are disturbed and killed, or reduced in numbers.

CROP ROTATION

The method of growing one crop one year and another crop the next year (crop rotation) also serves to control pests. For example, a certain disease may parasitize the crop grown one year and thrive and multiply. However, if the crop grown the next year is one the disease cannot attack, the disease organism has nothing to live on and dies off. The disease however is not eradicated, as it quickly reestablishes itself when the right conditions are presented in following years.

Septoria (the black spots): a disease pest in wheat

SUMMERFALLOW

In summerfallow, the soil is tilled from two to six times during the summer to get rid of persistent weeds. This happens because the roots of the weeds are exposed to the sun and dry up. No crop is planted the year the field is under summerfallow – or seeding may be delayed until the fall, as for winter wheat.

USE OF WEED-FREE SEED

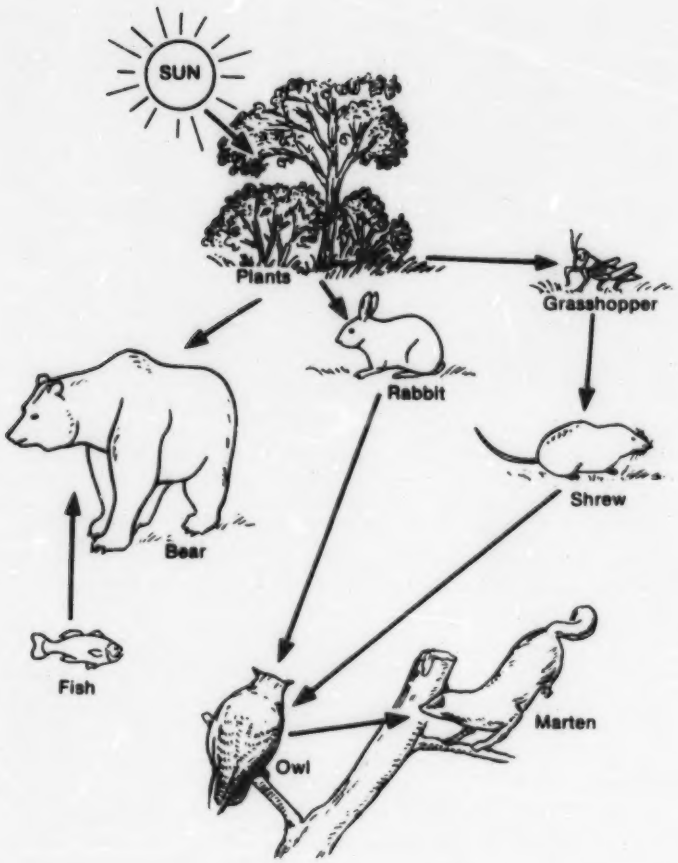
Another important method that farmers use to control weeds is to sow seed that is free of weed seeds. This process helps to prevent the proliferation or distribution of some troublesome weeds.

PEST RESISTANT SPECIES

Genetic selection is used to breed a crop that is more resistant to pest organisms. For example, certain crops in the grass family are resistant to the wheat stem sawfly because crops with stronger stalks were bred that keep the fly from eating through.

5.5 BIOLOGICAL CONTROL

Earlier, a natural wilderness environment was described as consisting of several species of plants, insects, animals, microorganisms, etc. all of which interact with each other. Thus, each species has one or several others that keep it from multiplying out of control. Generally, one species (a predator) uses another (the prey) for food. Or one species (a parasite) may lay its eggs into another (a host).



A natural environment showing the interaction of several species with each other.

Biological control uses a predator or a parasite of the pest for control

This concept of using a predator or a parasite to feed on or infect an agricultural pest is an attractive idea and is being pursued vigorously by scientists. If a predator or parasite can be introduced into the agricultural environment to attack that pest, control of that pest is possible. This technique of controlling one organism with another is called biological control.

Despite the appeal of biological control, development of such a method is lengthy, time-consuming, and costly. It requires considerable basic research to learn about the characteristics of the insect, its life cycle, its interaction in the environment and its predators. But although progress is slow in this area, some such methods have already been developed and are being used.

In greenhouses and some open environments biological methods are used.

For example, in greenhouses several biological methods are being used with success. This enclosed environment is particularly suitable for such a method of pest control since pest species are usually few, and little or no immigration of new pests occurs. Predators or parasites can be introduced into the greenhouse for each of the few pest species present.

This tiny wasp lays its eggs in the mealybug, a pest in greenhouses. When the eggs are hatched, the developing grubs feed on the mealybug – a good example of biological control.

Some biological methods are also being used in open environments such as forests and isolated citrus groves. For example, in forests, the bacterium **Bacillus thuringiensis,** or B.T., is used to control tent caterpillars of certain moths. In this situation, however, there is only one pest species, e.g., the tent caterpillars, and the bacterium is specific for that pest and no other. When there are several pests, as in orchards or citrus groves, or when the opportunity exists for the migration of pests, as occurs in an open environment, biological control of pests becomes difficult. Biological control is very specific: usually only one predator will control one pest; if there are several pests, then several predators and parasites are needed. To find so many safe predators or parasites is an extremely difficult task.

The forest tent caterpillar can be controlled by the bacterium, *Bacillus thuringiensis*.

Biological methods are desirable for pesticide – resistant pests.

Biological methods are especially desirable for pesticide-resistant pests. However, pests are also capable of developing resistance to biological control agents, although this process develops much slower than in the case of pesticide resistance.

For example, the disease "myxomatosis" was introduced into Australia to suppress the introduced rabbit population which had multiplied out of control and had become pests. The biological agent was very effective in controlling the rabbits initially, but today the animals are beginning to develop a resistance to the disease.

The development of resistance is part of the endless process of evolutionary adaptation to a changing environment. It occurs in response to all categories of change, whether man-made or from natural causes, and whether chemical, physical or biological. Species that do not evolve as needed to retain their position in the ecological food chain may become extinct.

5.6 INTEGRATED PEST MANAGEMENT

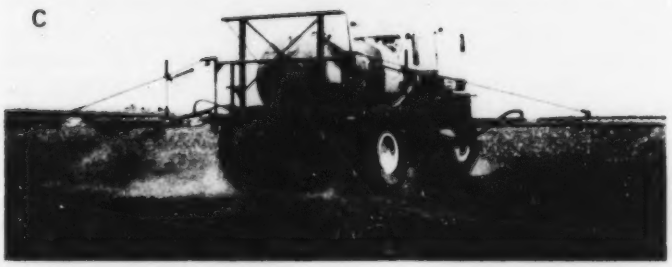
Integrated pest control uses a combination of cultural, biological and chemical methods.

If all the available methods of controlling pests are used in combination, rather than individually, more effective pest control can be achieved. Cultural, biological and chemical methods can be integrated into a total package of pest control called integrated pest management. This has been practised by farmers for many years. Tillage, crop rotation, summerfallow, and the use of weed-free seed are the cultural means employed to cut back on pest outbreaks. Predators or parasites are introduced when available and given maximum time to work. If pest populations are not reduced to an acceptable level, pesticides are then used. The idea of an integrated scheme is to allow non-chemical means of pest control a maximum chance to reduce the pest population. When this fails, chemical means are then used. Integrated pest management therefore emphasizes reduced chemical use.

A

B

C



Integrated pest management involves a combination of (A) cultural, (B) biological and (C) chemical means of controlling pests.

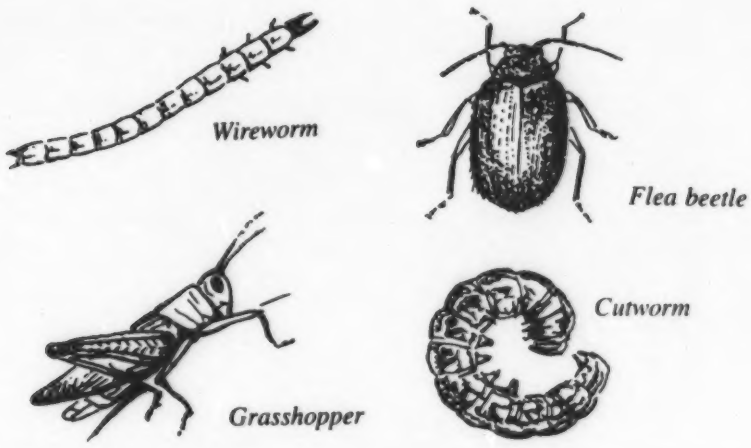
Farmers are now urged to seek the assistance of qualified pest managers in helping to manage their integrated programs.

A pest manager collecting samples to be checked in the laboratory for populations of pests and predators or parasites.

These managers check closely for the presence of pest and predator or parasite populations in crops and suggest if and when pesticides should be applied. This arrangement seems to be working well since in many instances farmers save money by not having to apply chemicals unnecessarily. The practice of integrated pest management is being encouraged to cut back on pesticide use thereby decreasing the problem of pest resistance to pesticides.

Integrated pest management can cut back on use of pesticides.

In Alberta, a few predators or parasites are known for the control of major pests such as grasshoppers, cutworms, bertha armyworms, etc.



Some major pests of Alberta

Testing these biological techniques is still in the laboratory stage and it will be several years before they are tested in the open environment. Therefore, the use of cultural and chemical methods of pest control predominate. However, populations of these pests are monitored every year and a forecast is provided to farmers to indicate whether or not pesticides will be required.

5.7 SUMMARY

Certain weeds, insects and microorganisms exploit the agricultural environment to rob us of a significant portion of our yearly harvest if they are not controlled. Farmers use many methods to control pests. Chemical methods mainly include the use of pesticides such as herbicides, insecticides and fungicides. The occurrence of resistance to pesticides has made it necessary for different methods of controlling pests to be found. The alternatives include cultural and biological control and integrated pest management. Cultural methods make use of tillage, crop rotation, summerfallow and the use of weed-free seed. Several biological control methods are used successfully in greenhouses, but many problems are experienced in open environments. Integrated pest management involves a combination of all existing methods of pest control. The main objective of this method is to cut back on the use of chemical pesticides in controlling pests.

5.8 QUESTIONS

1. Describe how insects may become resistant to insecticides.
2. What is a natural wilderness environment? How does this compare to the agricultural environment?
3. What is biological control?
4. What is integrated pest management?
5. Describe one cultural method of controlling pests in agriculture.

5.9 REFERENCES

1. McEwen, F.L. and G.R. Stephenson (1979).
   The Use and Significance of Pesticides in the Environment.
   John Wiley & Sons, Toronto.
2. **The Pesticide Gazette** (1984). Obtainable from the Alberta Agriculture office in your district. Published by the Environmental Resource Centre, 10511 Saskatchewan Drive, Edmonton. T6E 4S1.
3. **Integrated Pest Management,** 1982.
   A publication from the Council for Agricultural Science and Technology (CAST). Report #93.
4. **The Resistance of Agricultural Pests To Control Measures,** 1983. A publication from the Council for Agricultural Science and Technology (CAST).
   Report #97.
5. Steiner, M.Y. and D.P. Elliott (1983).
   Biological Pest Management For Interior Plantscapes.
   Alberta Environmental Centre, Vegreville.

CHAPTER 6

MISCELLANEOUS METHODS OF PEST CONTROL

6.1 INTRODUCTION

GOAL: To understand new and future methods of pest control

In addition to the use of chemical, cultural, biological or integrated methods to control pests, a number of novel methods have been tried, or are being studied. These are all aimed at reducing the amount of chemical pesticides being used, and to control pest species that have become resistant to chemicals. These methods make use of male sterilization, genetic manipulation, pheromones, attractants and hormones.

6.2 MALE STERILIZATION

Sterile males mated with wild females result in infertile eggs that do not hatch

For this method sterile males of the pest species are introduced into the wild population. Matings of the sterile males with wild females result in infertile eggs that do not hatch. Consequently, the pest population decreases.

At the start of a pest control program where male sterilization is used, the natural population of the pest must be flooded with many sterile males so that the population will continually diminish. The best time to introduce a pest control program using male sterilization is when the pest population is low. If the population is too high, it should be reduced by other means before a male sterilization program is implemented.

The males can be sterilized in the lab or in the wild.

Sterile males can be introduced into the natural population in two ways. For the first method, the males are mass produced and sterilized in the lab before they are released into the wild population. In the second method, a portion of the wild population is sterilized in the field. Insects in the lab are sterilized by irradiation whereas those in the field are sterilized by chemical sterilants (called chemosterilants).

Gamma radiation has been used extensively to sterilize warble flies which are then released into the population to compete with normal flies. The females, such as the one in the picture, will then lay infertile eggs. Research on sterilization of warble flies has been conducted at the Agriculture Canada Station, Lethbridge.

Male sterilization has produced some successful results.

Field trials of the male sterilization method have produced some successful results. On the island of Curacao, sterile male screwworm flies were released into the wild population, which was eradicated by the fourth generation. In Florida sterile male screwworm flies were released every week into the wild population to prevent movement of the pest to the south.

6.3 GENETIC MANIPULATION

Genetic manipulation encourages the spread of a defective gene throughout the population.

This is a new method which is now being studied in the lab and in small scale field experiments. In theory, an individual in the pest population with a defective gene is isolated. This mutant is then mated with the normal population to spread the defective gene. Eventually the entire population is defective and soon perishes. For example, during breeding studies with the fruit fly one mutation resulted in a vestigial wing (a wing that was no longer functional). This mutation could theoretically be bred into the entire population and the fruit flies would be virtually immobile and unable to travel to mate. The population would eventually die off. Another example where genetic manipulation could be used to control pests is in the spread of a defective gene which delays

hibernation of the pest. The pest would be unprepared when the cold weather arrives and would die.

6.4 PHEROMONES

Pheromones are chemical agents released by an organism into the environment. They allow organisms of the same species to communicate with each other. Most of the research on pheromones has been done on insects because of the pressing need to control insect pests resistant to chemicals.

Pheromones are produced from glands usually located in the abdomen, but they are sometimes located in the head or thorax of the insect.

The antenna on this cutworm moth detect sex pheromones released by the female

The chemicals which directly facilitate mating are sex pheromones. Usually they are produced by the female to attract the male. Males often have specific receptors in their antennae to detect low concentrations emitted by the females. Males are capable of finding the females over very long distances – the record is 11 km.

A pheromone insect trap

Pheromones are used for trapping, monitoring and mating disruption

Pheromones have been used in pest control in three distinct ways: mass trapping, mating disruption and in monitoring pest populations.

Where pest populations are low, mass trapping with a highly specific pheromone may catch enough of the target pests to control that species in a limited area. More refinement of this method is necessary.

Mating disruption involves the release of a high concentration of pheromone into a confined area. This confuses the males which are unable to locate the females for mating. The problem with this technique is that the high concentration of the pheromone is not maintained for long. A technique that allows a high concentration of the pheromone to be released slowly over a long period of time will have to be developed before this method can be successful.

Pheromones are used to monitor pest populations by placing female sex pheromones over a trap where males are caught when they are attracted to the bait. Monitoring is not a method of control but an indicator of the number of pests in the area.

Common name	Trade Name	Species attracted
disparlure	Disparmone Pherocon GM	gypsy moth
grandlure	Grandamone Pherocon BW	boll weevil
gossyplure	Pherocon PBW	pink bollworm
hexalure	Hexamone	pink bollworm
looplure	Cabblemone Pherocon CL	cabbage looper
muscalure	Muscamone	house fly
codlelure	Codlemone	codling moth
virelure	none	tobacco budworm
none	Z-11	red-banded leaf roller European corn borer oblique-banded leaf roller smartweed borer

Permission to reprint requested

Some of the commercially available synthetic insect sex pheromones.

6.5 ATTRACTANTS

Attractants include light, chemicals, sound and vibrations

Attractants can be used to localize a pest to allow for a minimal amount of chemical to be used for control. Attractants include light, chemicals, sound and vibrations e.g., moths are attracted to lights.

6.6 GROWTH HORMONES

Artificial growth hormones can confuse the natural ones in a pest

Insect growth hormones are a recently developed group of pest control chemicals. One group, the avermectins, are very effective in controlling pests in cattle and do not affect the nervous system of animals. Other growth hormones are being developed that may alter the physiology of the insect pest. They may be used to force the insect into its over-wintering state at a time when it should be reproductively active, or to develop eggs at a time they would have no hope of surviving.

6.7 SUMMARY

Several methods of pest control are currently being studied in an effort to control pest species that are resistant to chemicals and to reduce the need for chemical pesticides. The methods which have been covered are: male sterilization, genetic manipulation, pheromones, attractants and growth hormones.

6.8 QUESTIONS

1. Name five attractants.
2. Explain what genetic control is.
3. What are the two ways to introduce sterile males into the population?
4. What are three points to consider when applying the sterile male technique?
5. What are three ways pheromones are used in pest control?

6.9 REFERENCES

1. Woods, Arthur (1974).
   Pest Control. McGraw-Hill Book Company (UK) Limited, England.
2. Ware, George W. (1978).
   The Pesticide Book. W.H. Freeman and Company, San Francisco.

CONCLUSION

For many of us, our familiarity with agriculture begins and ends with the food we see in the supermarket: delicious apples, pears, and peaches; fresh green vegetables; fresh dairy products; and excellent meats and poultry. Diseased fruits, rotten potatoes, worm-laden vegetables, and weevil-infested flour are things of the past.

There is no doubt that we, as Canadians, enjoy an abundance of highly nutritious food. Hunger and starvation are not prevalent in Canada. Because we are not faced with the want for food, the importance of agriculture or the role of the farmer in bringing us that food is often ignored. We simply take it for granted that our supermarkets must have excellent quality foods at all times. But farmers expend a lot of energy to bring us that food: to prepare the soil; sow their crops; get rid of weeds, insects and diseases that rob them of their production; and harvest and store their produce.

This text was compiled to make the students familiar with some of the factors involved in the production of food: the position of Canada as a world food producer; the efforts of farmers to practise good farming and to keep pest damage to low levels; the past successes of pesticides in saving human lives and their side effects on wildlife; government control over pesticides; and new approaches to pest control.

ACKNOWLEDGEMENTS

My sincere thanks to Gary Popowich of the Alberta Department of Education for his encouragement and support in the preparation of this text and for introducing this subject into the educational system in Alberta. I would also like to thank Lori Benner for her contributions in the writing of this text. My appreciation is also extended to Sheila Majeau for typing this manuscript.

TEACHERS GUIDE

Chapter 1 (1.1-1.3) of Pest Control in Canada corresponds with chapter 32 (32.1-32.9) of "Biology – Living Systems".

Section 1.1 introduces the chapter and tells two ways how pests came to be: by thriving when the land was changed from a natural state to agricultural, and by being imported.

Section 1.2 uses biotic potential, population growth curves and limiting factors learned in chapter 32 to explain what makes an organism a pest as it pertains to agriculture.

Section 1.3 uses predator, prey, parasite and host relationships to describe how the natural environment maintained its balance.

**It takes approximately 7 minutes to read these sections.

Chapter 1 (1.4-1.8) in this book follows section 32.10 and 32.11 in the Biology 20 text.

Section 1.4 discusses the change in the natural environment that occurred when the first settlers arrived.

Section 1.5 tells how the pests prospered on cultivated land.

Section 1.6 summarizes the chapter.

**It takes approximately 5 minutes to read these sections.

Section 1.7 contains four questions pertaining to materials presented in chapter 1.

Section 1.8 suggested activities:
1. 30 minute film "Pest Wars"
2. Identify pests in a home vegetable garden from "Backyard Pest Management".

Chapter 2 (2.1-2.3) also follows sections 32.10, 32.11 and 32.12 in the Biology 20 text.

Section 2.1 introduces chapter 2. It expands on the developments of agriculture.

Section 2.2 explains how food is a product of agriculture and that a small portion of our population grows this food. It covers the problems the pioneer farmer faced of hard work, natural elements and pests, plus the technology that brought dramatic changes after the Second World War. It discusses that farmers found advantages in specializing in the crops they grew.

Section 2.3 discusses the new technology that enabled large areas of land to be used for food production by only a small percentage of farmers.

**It takes approximately 6 minutes to read these sections.

Section 2.4 contains four questions on material covered in chapter 2.

Section 2.5 suggested activities
1. Look at supermarket advertisements to identify where the food was grown.
2. Identify farm animals and the food products obtained from them.

Comment on Agriculture – a short comment on the agricultural industry in general.

Chapter 3 (3.1 and 3.2) in this book follows chapter 33 (33.1 to 33.3) in Biology – Living Systems.

Section 3.1 introduces the discovery of DDT (which is touched upon briefly in chapter 35 of "Biology")

Section 3.2 discusses the early pesticides, both the beneficial effects of disease eradication plus the problems of persistence, cancer-causing and their presence in food and water. Knowledge of the food chain and the biomass of an ecosystem leads to an understanding of the accumulation of DDT at the top of the food chain and the effects of this on the top level consumers.

Section 3.3 covers monitoring studies done to determine the levels of pesticides in the prairie environment, plus describes what the measurements of the studies mean.

Section 3.4 summarizes chapter 3 about modern and early pesticides.

**It takes approximately 9 minutes to read these sections.

Section 3.5 contains 4 questions on the material in chapter 3

Section 3.6 suggested activities
1. View short film "From Soil to Table" (15 minutes)
2. A visit to a government pesticide analysis lab is suggested

Chapter 4 (4.1 to 4.7) in this book can follow chapter 35 of Biology – Living Systems (35.1 to 35.4) but need not.

Section 4.1 introduces how the government ensures the safety of pesticides to consumers.

Section 4.2 reviews the pesticide approval process from discovery and initial testing to final approval.

Section 4.3 describes the features and importance of the pesticide label.

Section 4.4 tells how food is monitored by the government for pesticides.

Section 4.5 summarizes the chapter.

**It takes approximately 10 minutes to read these sections.

Section 4.6 contains five questions to answer about chapter 4 with question number five being a discussion of potential problems of pesticides.

Section 4.7 suggested activities
1. Obtain a pesticide label and identify the information.
2. Review the items on the label appearing in the **Pesticide Gazette** which can be obtained from Alberta Agriculture (403) 427-2121.

Chapters 5 and 6 in this book correspond with chapter 35 (35.1 to 35.4 and 35.14) in the text book Biology – Living Systems.

Section 5.1 introduces four methods of pest control: chemical, cultural, biological and integrated pest management

Section 5.2 discusses chemical control and different types of pesticides: herbicides, fungicides and insecticides, and how they act upon the pest.

Section 5.3 explains pests resistance to chemicals and the need for alternate methods to overcome this resistance.

Section 5.4 covers cultural pest control methods: tillage, crop rotation, summerfallow, use of weed-free seed, and pest resistant species.

Secetion 5.5 discusses biological control methods: the methods currently in use and the research that is still required. It also tells about resistance that can develop.

Section 5.6 explains how integrated pest management combines chemical cultural and biological control methods.

Section 5.7 summarizes chapter 5

**It takes approximately 20 minutes to read these sections.

Section 5.8 contains five questions pertaining to material in chapter 5.

Chapter 6

Section 6.1 introduces some new methods of pest control such as: male sterilization, genetic manipulation, pheromone use, attractants and hormones.

Section 6.2 describes the male sterilization method of pest control. The two methods of sterilization, how it works and as a result – infertile eggs.

Section 6.3 describes how genetic manipulation can encourage the spread of a defective gene throughout a population.

Section 6.4 discusses the use of pheromones for trapping, monitoring and the mating disruption of pests.

Section 6.5 tells how attractants such as light, chemicals, sound and vibrations can localize a pest for minimal chemical control.

Section 6.6 looks at growth hormones and how artificial ones can confuse the natural ones in a pest resulting in death.

Section 6.7 is a summary of chapter 6

**It takes approximately 6 minutes to read these sections.

Section 6.8 contains five questions on these new methods of pest control.